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OGMODIRUS MARTINII, A NEW PLESIOSAUR FROM THE CRETACEOUS OF KANSAS. . . . . *S. W. Williston and Roy L. Moodie*

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Ogmodirus martinii, a New Plesiosaur from the Cretaceous of Kansas.

BY S. W. WILLISTON,
Department of Palentology, University of Chicago; and
ROY L. MOODIE,
Department of Anatomy, University of Illinois, Chicago.

THERE have been recorded from the Cretaceous deposits of Kansas five genera and sixteen species of plesiosaurs, as follows:

From the Comanche (in the restricted sense of the term), two species referred provisionally to *Plesiosaurus;* from the Benton, two species of *Trinacromerum* (including the genotype), one of *Brachauchenius*, the genotype, and one of *Elasmosaurus;* from the Niobrara, five species of *Elasmosaurus*, two of *Polycotylus*, including the genotype, and one of *Trinacromerum;* from the Fort Pierre, the genotype of *Elasmosaurus*, and one species referred provisionally to *Plesiosaurus*. Of the above, doubtless all those referred to *Plesiosaurus* belong to other as yet unrecognized genera; and in much probability several of those referred to *Elasmosaurus* from the Benton and Niobrara will be found eventually to pertain to other genera. One of these, especially *E. ischiadicus* Will., quite surely does not belong in that genus and may belong in the present genus. It was originally described as a problematical species of *Polycotylus* because of its short cervical vertebræ, but later quite surely eliminated from that genus because of its short ischia. For the present it may find a location in the following genus.

The present genus, *Ogmodirus*, from the Cretaceous of Cloud county, Kansas, is of peculiar interest in presenting certain intermediate characters between the Elasmosauridæ and Plesiosauridæ, the two distinctive families of long-necked plesiosaurs. The two families differ, aside from the skull, especially in the

structure of the pectoral girdle. The characters of the genus *Elasmosaurus* have been given by the senior author[1] as follows:

"Symphysis of mandibles short; teeth markedly anisodont. Neck with seventy-six true cervical vertebræ and three pectorals, the centra increasing in length to the fifty-eighth, and then decreasing in length to the dorsals, thence nearly uniform in length throughout the dorsal region. Posterior cervicals and dorsals much wider than high, and wider than long; spines wide and not high; zygapophyses weak. Pectoral girdle with large scapulæ meeting each other in the middle line. No interclavicular foramen; coracoids broadly separated posterior to the interglenoid thickening, their posterior ends not much dilated. Cervical ribs single headed. Ischia short."

Of these characters the number of cervicals is doubtless a specific character; the species *E. serpentinus* has but sixty cervicals. The elongation of the posterior cervicals is undoubtedly a real generic character, and is common to various species. The approximation of the scapulæ and absence of the interclavicular foramen, and also, in much probability, of the interclavicle, may or may not be of family value. The European forms referred to this family do not have, so far as published, the broad separation of the coracoids posteriorly. It is very probable that, when the skulls have been more attentively compared, *Cryptocleidus* and its allies will be excluded from the family Elasmosauridæ.

That the present genus is distinct from *Elasmosaurus* is evident. Until its skull and pectoral girdle are known its position in the family is doubtful. The only other long-necked genus with which it can be compared is *Leurospondylus* Brown,[2] recently described. So far as the description and figures of that genus apply to the present material the two genera can not be distinguished.

The material upon which *Ogmodirus* is based is represented by the following parts: fifty-one consecutive cervical vertebræ, eighteen caudal vertebræ, humerus, femur, many carpal and phalangeal bones, the right ilium, a part of a pubis, and various fragments of ribs and neural spines. This material was collected in 1909 by Mr. C. Boyce in Cloud county, Kansas, associated with the remains of another plesiosaur, and presented by him to the University of Kansas. Its horizon is probably the Fort Hays limestone of the basal Niobrara, though possibly, but improbably, from the uppermost horizon of the Benton. The species has been named in honor of Mr. H. T. Martin, in appreciation of his long,

1. Williston, S. W. 1906. North American Plesiosaurs: *Elasmosaurus, Cimoliasaurus* and *Polycotylus*. Amer. Journ. Sci., 4th ser., vol. xxi, No. 123, March, p. 225.

2. Brown, Barnum. 1913. A New Plesiosaur, *Leurospondylus*, from the Edmonton Cretaceous of Alberta. Bull. Amer. Mus. Natl. Hist., vol. xxxii, art. xl, pp. 605-615, figs. 1-7. December.

faithful and intelligent work in the Cretaceous deposits of Kansas for the University of Kansas.

The genus *Ogmodirus* (ὄγμος drawn out in a straight line and δειρη neck) has been defined as follows:[3]

Cervical vertebræ short, almost as wide as long, gradually increasing in size. The length and breadth are proportionate, as is indicated in the following table of measurements:

		Length.	Width.
Cervical vertebra	1	0.020 m.	0.030 m.
Cervical vertebra	6	0.023 m.	0.032 m.
Cervical vertebra	12	0.030 m.	0.038 m.
Cervical vertebra	20	0.034 m.	0.044 m.
Cervical vertebra	30	0.041 m.	0.052 m.
Cervical vertebra	40	0.045 m.	0.067 m.
Cervical vertebra	45	0.045 m.	0.067 m.
Cervical vertebra	51	0.046 m.	0.072 m.

Since there is nothing present of either the atlas or axis, the first cervical vertebra preserved must be at least the third of the series, possibly a later one. At any rate it is the first of the series preserved. No cervical ribs are preserved complete, though there are fragments of them. The rib facettes are present throughout the cervical series. (Fig. 1, text.) For a member of the Elasmosauridæ the neck is not extraordinarily long, containing probably about sixty vertebræ, and measuring about 2 meters. The paddles are not expansive, but short and thick, with the metacarpals and phalanges short and heavy.

The fore limb (plate II) has a complete length of 0.600 m., of which 0.152 m. belongs to the propodium, 0.050 m. to the mesopodium, 0.070 m. to the metapodium, and about 0.300 m. to the digital portion. This is making no allowance for the cartilage, ligaments and integument, which doubtless adds several millimeters to the length as given.

Cervical vertebræ. These centra are, as usual, nearly amphiplatyan. On the visceral surface they are, throughout the series, perforated by a pair of vascular foramina (plate IV, fig. 5), which have a diameter of 2 mm. On the fifteenth vertebra preserved this opening measures 6 mm. There are two articular surfaces for the articulation of the ribs (plate I). These articular surfaces gradually increase in size toward the dorsal region. On the third cervical they possess a length of 11 mm. and a breadth of 8 mm.; on the fifteenth a length of 18 mm. and a breadth of 14 mm. Superficially there appears over all the cervical centra many

3. Williston, S. W., and Moodie, Roy L. 1913. A New Plesiosaurian Genus from the Cretaceous of Kansas. Bull. Geol. Soc. Amer., vol. 24, No. 1, pp. 120, 121. March.

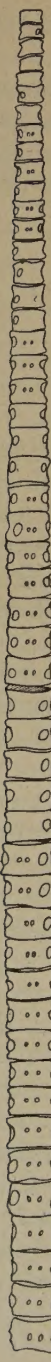

FIG. 1. The cervical vertebræ of *Ogmodirus martinii* drawn from the ventral side. The series is incomplete at both ends.

punctiform vascular pits and canals (plate IV, fig. 5), doubtless indicating a rich periosteal blood supply. The articular facttes for the neural arches are egg shaped, possessing a length of 31 mm. and a breadth of 15 mm. of the fifteenth vertebra. Between the articular facettes for the neural arch lies the shallow, hourglass-shaped canal for the spinal cord, or rather the meningeal canal. In the center of the canal occur two egg-shaped vascular pits. The centra are slightly constricted in the middle of the bone, although the visceral portion is larger than the neural portion, owing to the presence of the costal articulations.

The articular surfaces for the *neural spines* are identical in the most anterior and in the most posterior. They are oval in shape, with the central point most depressed. Between the depressions for the neural spines superiorly there are two nutrient foramina corresponding in position and undoubtedly in function to the ventral structures of the same.

The diapophysis stands out moderately; vertically elongate, apparently connected by a narrow surface upward on the arch. The lower extremity of the articular surface, however, reaches pretty well down on the ventrum.

Transverse diameter of the centrum	84
Vertical diameter of the centrum	78
Length	45–48

The better of the two dorsals is deeply cupped, circular in outline, with rather sharp rims, rather deeply concave on the sides and below and circular in cross section through middle. Vascular foramen situated high up on the sides, above the middle.

Length below	55
Length above	51
Transverse diameter	100
Vertical diameter	92

Only a few much water-worn fragments of spinous processes are preserved (plate IV, fig. 3); of the neural arch nothing is at hand. One of the best-preserved neural spines is deeply scarred by the teeth of some predaceous Cretaceous fish. The neural spine possesses a height of 85 mm. and a breadth of 31 mm. Outwardly the spine is smooth, the apex roughened for a cartilaginous tip, apparently indicating an immature animal.

The neural spines are relatively heavy, broad, and laterally flattened. Only fragments of them are preserved, but one of these fragments consists of a nearly complete spine. The tip was capped by a large amount of cartilage, another indication of the youthful

character of the individual. The edges are roughened for muscular attachment and the sides are smooth. The zygapophyses are rounded and saddle-shaped.

Measurements of Cervical Vertebræ.

(No. 441, University of Kansas Museum of Natural History.)

Length of most anterior vertebra preserved	20 mm.
Width of most anterior vertebra preserved	28 mm.
Height of most anterior vertebra preserved	17 mm.
Median width of neural canal	5 mm.
Length of the most posterior vertebra preserved	45 mm.
Width of same	70 mm.
Height of same	43 mm.

Measurements of Neural Spine.

(Possibly associated with the cervical vertebræ.)

Height of single spine preserved	85 mm.
Dorsal width	30 mm.
Ventral width	36 mm.

Among the material brought in by Mr. Boyce there was a string of eighteen caudal vertebræ which are possibly to be associated in this species. We will at least place them there provisionally until such a time as further information will permit their exact identification. They consist of four pygals and fourteen caudals. The pygals differ in form from the most posterior caudals, but have essentially the structure exhibited by the cervicals, *i. e.*, short, heavy, depressed, with lateral rib articulations. The most anterior pygal differs from the cervicals in being shorter, with the neurocentral articular surfaces wider apart, and the rib articular surfaces larger, the reduction in size of the nutrient foramina and the more marked amphicœlous character of the centra. This will sufficiently characterize the pygals. The caudals differ from the pygals in a further reduction along these same lines.

Measurements of the Pygals and Caudals.

Length of most anterior pygal	31 mm.
Width of same	60 mm.
Height of same	36 mm.
Diameter of neural canal	15 mm.
Length of rib articular surfaces	20 mm.
Width of rib articular surfaces	18 mm.
Length of most posterior caudal	23 mm.
Width of same	54 mm.
Height of same	38 mm.
Diameter of neural canal	9 mm.

The neurocentral articular surfaces are divided into two portions, separated by the rib articular surface. The most anterior of the pygals indicates a sacral intumescence for the hind limbs. Just what its size in proportion to the brain may be would be an interesting matter. The intumescence extends through several of the vertebræ and indicates an active use of the limbs as propelling organs. The most posterior cervical preserved has no indication of such an intumescence, so we must conclude that the neck is still incompletely represented even with the fifty-one vertebræ, and may have included six or eight more. Certainly none of the vertebræ described above as cervical belong to the dorsal series.

Forelimb. There was enough material present, although badly scattered, which seemed to belong to a single member, to reconstruct (plate II) a paddle which has been referred to the left side. This limb has a total length of 0.600 m., of which 0.152 m. belongs to the humerus, 0.050 m. to the radius and ulna, 0.070 m. to the carpals, and perhaps 0.300 m. to the digital division, although the distal phalanges are lost. The breadth of the limb at the level of the radius is 0.150 m., at the carpus 0.130 m. and at the third phalangeal row 0.120 m.

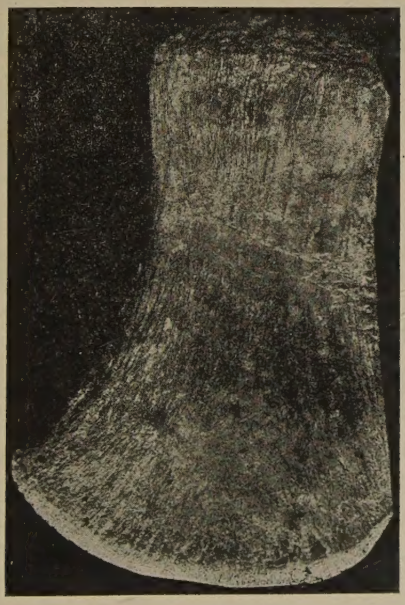

FIG. 2. The humerus of *Ogmodirus martinii* from the ventral side.

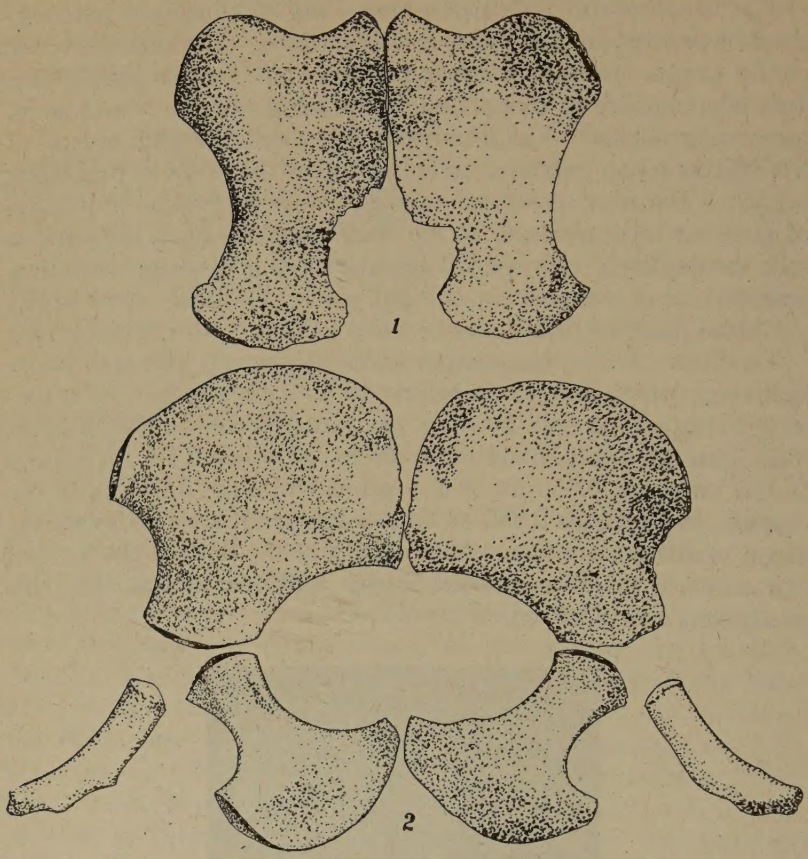

Fig. 3. (1) The coracoids of *Leurospondylus*. After Brown.
(2) The pelvic girdle of *Leurospondylus*. After Brown.
These figures are inserted here for the sake of completeness. The form described by Brown is very similar to *Ogmodirus*, and the parts of the skeleton which he figured and described are lacking in the present form.

The *humerus* is associated with the paddle remains provisionally. They were scattered and dissociated when the specimen was brought to the museum. It is possible that portions of two paddles are represented. The element is well characterized in the figure (plate III, fig. 1, and text fig. 2). It is short, heavy and thick, extremely so for a plesiosaur. Its lower surface is flattened and relatively smooth, with a slight tuberculation near the proximal end for muscular attachment. The ends are marked with pits and cones (plate III, figs. 2 and 4), resembling minature volcanoes. These pits and mounds doubtless indicate the fact of

emigration of the osteoblastic tissue from the medullary canal, which in this species is highly developed. The mounds correspond to the points of entrance of the *Canalis ossificans perforans*, which in mammals transmit the osteoblasts from the medullary portion of the diaphysis into the epiphysis. The element is regarded as a humerus simply on account of its shortness, since it has heretofore been an invariable rule among the plesiosaurs that the shorter propodial is the humerus.

The humerus is remarkably short and broad, thickened at the proximal end, so that at this point it shows a rounded outline in cross section. The element gradually expands distally, especially toward the median plane, so that finally the distal end appears partly separated by an indentation. On the upper surface the bone has been distinctly marked on the radial edge (plate III, fig. 1) by the teeth of some predaceous fish or reptile, inflicted shortly after the death of the animal. This is not a rare occurrence among Kansas Cretaceous fossils, and indicates that some of the Cretaceous vertebrates were carrion feeders.

There are no well-developed facettes on the ends of the humerus such as is so common among other plesiosaurian species.

Measurements of Humerus.

Length	0.152 m.
Width at proximal end	0.070 m.
Width at middle	0.071 m.
Width at distal end	0.112 m.
Thickness at proximal end	0.050 m.
Thickness at distal end	0.036 m.

The *radius* and *ulna* are flattened, rounded plates, with broad peripheral surfaces for articular cartilage. The ulna is much smaller than the radius and is more nearly rounded. The radius is elongate transversely, with the ventral surface concave and marked by several vascular pits. (Plate II.)

Measurements of Ulna.

Greatest breadth	47 mm.
Least breadth	42 mm.
Greatest thickness	21 mm.

Measurements of Radius.

Greatest breadth	70 mm.
Least breadth	52 mm.
Greatest thickness	25 mm.

The *carpals* (plate II) are of the same character as the radius and ulna. They can only be distinguished by size. The largest

of the carpals is regarded as the centrale. It is in the form of a rounded triangle. Its measurements are:

Greatest breadth	50 mm.
Least breadth	44 mm.
Thickness	20 mm.

The smallest carpal element is rounded, measuring 27 mm. in diameter.

The *phalanges* (plate II) vary in shape. There are twenty-three preserved. One or more of them may be modified carpals, but they are indistinguishable from phalanges. The broadest phalanx measures 29 mm. Its shaft is marked by a prominent pit which leads into a medullary cavity similar to that of the femur.

Breadth of the smallest carpal	0.028 m.
Breadth of the largest carpal	0.050 m.
Length of the largest carpal	0.041 m.

The first phalanx has a medullary cavity filled with calcite. From this cavity canals lead to the upper and lower surfaces, as in the humerus. The ends exhibit surfaces which were apparently covered with a richly vascular cartilage. It is quite evident that all of the carpal elements were embedded in a mass of cartilage and that possibly this cartilage included the ends of the proximal phalanges.

The phalanges of the second, third, fourth and fifth digits consist of cylindrical elements, with thickened ends.

Measurements of the Metacarpals and Phalanges.

Length of metacarpal I	0.033 m.
Length of phalanx I of digit I	0.032 m.
Length of metacarpal I	0.035 m.
Length of smallest phalanx in the first digit	0.020 m.

The *pelvic girdle* is represented by an incomplete pubis (plate IV, fig. 4) and an ilium belonging to the right side. The ilium is a slender, smooth, somewhat crushed bone, with expanded distal articular surfaces. The median portion of the ilium is somewhat constricted. At the proximal ends it is obliquely expanded for articulation with the sacral rib. The distal end is rounded, and is marked by numerous small vascular pits and canals. The ilium, like the humerus, is marked by the teeth of some Cretaceous fish.

Measurements of the Ilium.

Length	0.148 m.
Width at proximal end	0.018 m.
Width at distal end	0.054 m.
Length of the sacral rib articular fossa	0.043 m.
Width of the sacral rib articular fossa	0.028 m.

The portion of the pubis (plate IV, fig. 4) consists of the articular portion. It is marked, as are the other elements of the skeleton, by fine vascular pits and lines. The diameter of the articular end is 0.037 m.

Hind paddle. The left femur of the hind limb is preserved. It is distinguished from the humerus by its slender, nearly straight form (plate IV, fig. 1) and its almost circular cross-section at the proximal end. There are no sharply defined articular facettes. On the superior surface there is a roughened process for strong muscular attachment. Its position is such that this process can be regarded in a certain sense as a trochanter.

On the radial surface of the femur there is a distinct rounded foramen, similar to those described by the writers elsewhere. Since the bone is broken at the plane of this foramen, it shows that the foramen is the opening of an elongate rounded canal, which in turn leads into a large medullary cavity which sends spicular spaces into the surrounding bone. (Plate III, fig. 3.) This condition has been commented on several times, but no explanation has been offered to explain it. The structure has all of the appearance of the so-called "periosteal buds" so commonly figured in textbooks of microscopic anatomy.

Measurements of the Femur.

Length	0.175 m.
Diameter of the lateral foramen	0.006 m.
Diameter of the medullary cavity	0.015 m.
Length of the canal	0.020 m.
Length of the medullary cavity	0.025 m.
Length of one of the smaller canals	0.001 m.

In view of the possibility of identity, or at least a close relationship, between *Ogmodirus* and *Embaphias circulosus* Cope, we give herewith figures of the best of the type specimen of this genus and species (plate V) as it is now preserved in the Academy of Natural Sciences of Philadelphia. The type, collected by Mr. F. H. Charles from the Great Bend of the Missouri river, South Dakota, in 1893, consists of two dorsal and one cervical vertebra. The specimens present no generic characters and can not be again

recognized until more complete specimens from the same locality and horizon are studied. That they belong to a short-necked plesiosaur is probable, and this may be *Polycotylus* or something allied to it; though if the horizon is the Pierre Cretaceous, as is probable, the generic identity would be more doubtful. The greater concavity of the dorsal centra also indicates a distinct genus.

The cervical is flattened, nearly circular in outline, rather strongly concave; a single large vascular foramen below, but no ridge or fossæ, but very slightly concave from margin to margin. The articular rim encroaches much on the exterior.

The diapophyses stand out moderately; vertically elongate, connected by a narrow surface upward on the arch. The lower extremity of the articular surface, however, reaches pretty well down on the ventrum.

Transverse diameter of the centrum	84 mm.
Vertical diameter of the centrum	78 mm.
Length	45-48 mm.

The better of the two dorsals is deeply cupped, circular in outline, with rather sharp rims, rather deeply concave on the sides and below, and circular in cross-section through the middle; vascular foramen situated high up on sides, above the middle.

Length below	55 mm.
Length above	51 mm.
Transverse diameter	100 mm.
Vertical diameter	92 mm.

DESCRIPTION OF PLATES.

PLATE I.

The cervical vertebræ of *Ogmodirus martinii*, photographed from the ventral surface. $\frac{1}{3}$ natural size.

PLATE II.

The left fore paddle of *Ogmodirus martinii*, photographed from the dorsal surface. The elements are of doubtful association. $\frac{1}{3}$ natural size.

PLATE III.

Fig. 1. The right humerus of *Ogmodirus martinii*, photographed from the dorsal surface and showing at *S* the tooth marks of some predaceous fish. $\frac{1}{2}$ natural size.

Fig. 2. The distal end of the humerus, showing the pits and cones, resembling miniature volcanoes, the results doubtless of the exit of the *Canales ossificantes perforantes* carrying osteoblasts. $\frac{1}{2}$ natural size.

Fig. 3. A photograph of a broken section through the femur. This section shows, on the right, the canal leading into the calcite-filled cavity. These features are apparently growth characters.

Fig. 4. A photograph of the proximal end of the humerus to show at *A* the pits and cones.

PLATE IV.

FIG. 1. The left femur of *Ogmodirus martinii*. $\frac{1}{3}$ natural size.
FIG. 2. Neural spines.
FIG. 3. The right ilium.
FIG. 4. A portion of a pubis.
FIG. 5. Two views of a cervical vertebra.

PLATE V.

The vertebræ of the type of *Embaphias circulosus* Cope. Specimens in the Academy of Natural Sciences of Philadelphia: 1 and 2, lateral and end views of vertebra; 3 and 4, lateral and end views of other vertebra.

OGMODIRUS MARTINII.
Williston and Moodie.

PLATE I.

OGMODIRUS MARTINII.
Williston and Moodie.

PLATE II.

OGMODIRUS MARTINII.
Williston and Moodie.

PLATE III.

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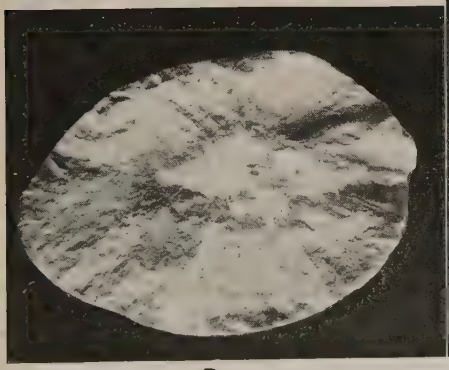

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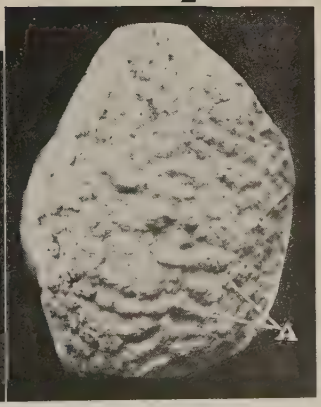

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OGMODIRUS MARTINII.
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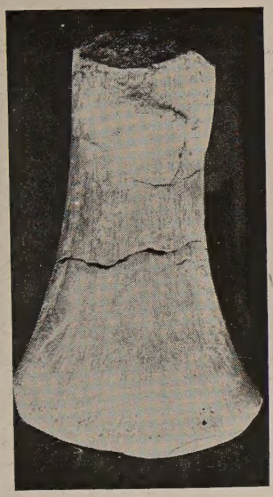
PLATE IV.



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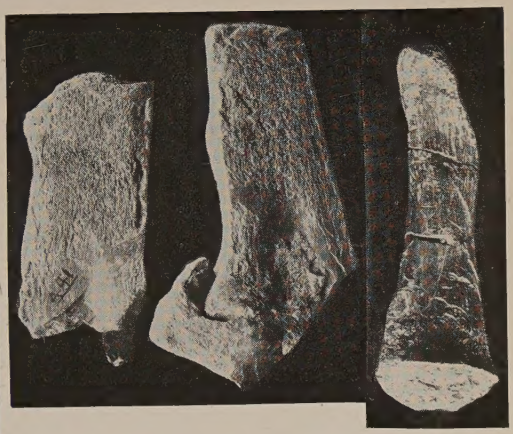

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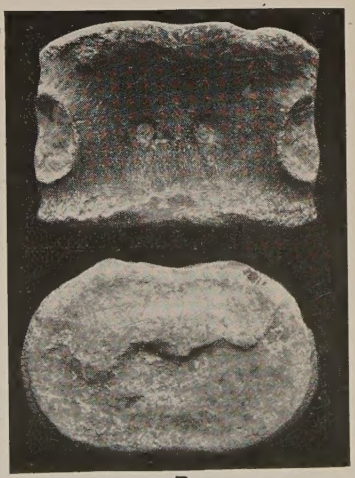

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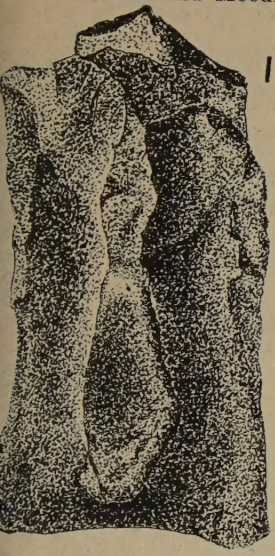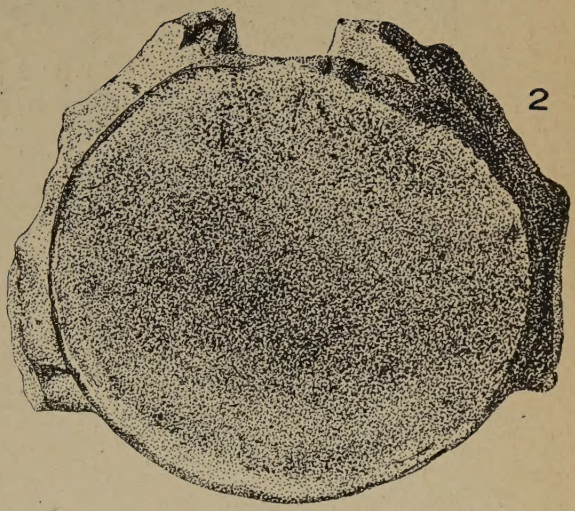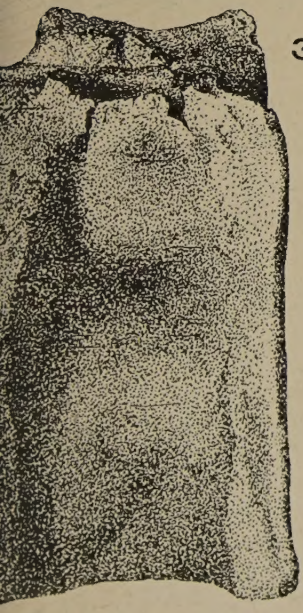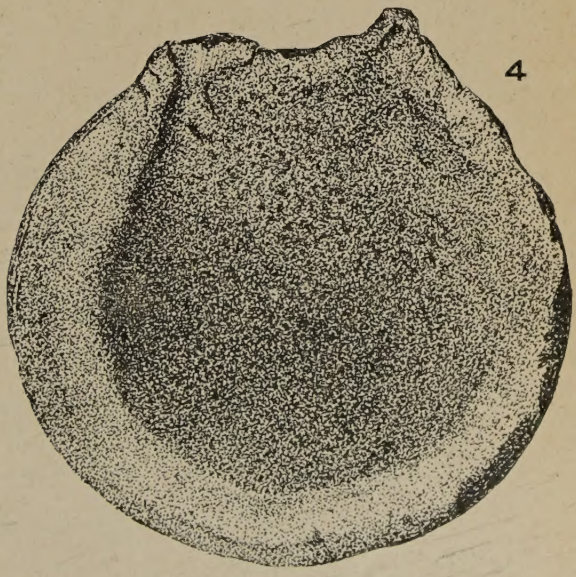
PLATE V.